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Hydrodynamical instability with noise in the Keplerian accretion disks: modified Landau equation

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Abstract:
The origin of hydrodynamical instability and turbulence in the Keplerian accretion disk is a long-standing puzzle. The flow therein is linearly stable. Here we explore the evolution of perturbation in this flow in the presence of an additional force. Such a force, which is expected to be stochastic in nature hence behaving as noise, could result from thermal fluctuations (however small be), Brownian ratchet, grain–fluid interactions, feedback from outflows in astrophysical disks, etc. We essentially establish the evolution of nonlinear perturbation in the presence of Coriolis and external forces, which is the modified Landau equation. We obtain that even in the linear regime, under suitable forcing and Reynolds number, the otherwise least stable perturbation evolves to a very large saturated amplitude, leading to nonlinearity and plausible turbulence. Hence, forcing essentially leads a linear stable mode to unstable. We further show that nonlinear perturbation diverges at a shorter time-scale in the presence of force, leading to a fast transition to turbulence. Interestingly, the emergence of nonlinearity depends only on the force but not on the initial amplitude of perturbation, unlike the original Landau equation-based solution.

Reference:
Ghosh, S., Mukhopadhyay, B., 2020, MNRAS, 496, 4191

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